HyNet North West Hydrogen Pipeline

Delivering clean growth

Appendix 9B
Dispersion Modelling

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ADMS-Roads Model

Introduction

The ADMS-Roads dispersion model (hereafter referred to as 'ADMS-Roads'), developed by Cambridge Environmental Research Consultants (CERC)[6], is a tool for investigating air pollution problems. It calculates pollutant concentrations over specified domains at high spatial resolution (street scale) and in a format suitable for direct comparison with a wide variety of air quality standards for the UK and other countries. The latest version of the model, version 5.0.1, was used in this assessment.

ADMS-Roads is referred to as an advanced Gaussian or, new generation, dispersion model as it incorporates the latest understanding of the boundary layer structure. It differs from old generation models such as ISC, R91 and CALINE in two main respects:

- It characterises the boundary layer structure and stability using the boundary layer depth and Monin-Obukhov length to calculate height-dependent wind speed and turbulence, rather than using the simpler Pasquill-Gifford stability category approach; and
- It uses a skewed-Gaussian vertical concentration profile in convective meteorological conditions to represent the effect of thermally generated turbulence.

Model Features

A description of the science used in ADMS-Roads and the supporting technical references can be found in the model's User Guide[1]. The main features of ADMS-Roads are:

- it is an advanced gaussian, "new generation" dispersion model;
- includes a meteorological pre-processor which calculates boundary layer parameters from a variety of input data e.g. wind speed, day, time, cloud cover and air temperature;
- models the full range of source types encountered in urban areas including industrial sources (up to 3 point sources, up to 3 line sources, up to 4 area sources, up to 25 volume sources) and road sources (up to 150 roads, each with 50 vertices);
- generates output in terms of average concentrations for averaging times from 15 minutes to 1 year, percentile values and exceedances of threshold values. Averages can be specified as rolling (running) averages or maximum daily values;
- the option to calculate emissions from traffic count data, speed and fleet split (light duty/heavy duty vehicles) using UK emission factors. Alternatively, road emissions may be entered directly as user specified values;

[1] Cambridge Environmental Research Consultants (CERC) (2016). ADMS-Roads, an Air Quality Management System User Guide version 5.2. (Online). Available from: https://www.cerc.co.uk/environmental-software/user-guides.html (Accessed July 2022)

- models plume rise by solving the integral conservation equations for mass, momentum and heat;
- models the effect of street canyons on concentrations within the canyon and vehicle–induced turbulence using a formulation based on the Danish OSPM model. it is usually only important to model street canyons when the aspect ratio (ratio of the height of buildings along the road to the width of the road) is greater than 0.5;
- models the effects of noise barriers on concentrations outside the road;
- models Nitrous Dioxide (NO_X) chemistry using the 8 reaction generic reaction set plus transformation of Sulphur Dioxide (SO_2) to sulphate particles, which are added to the Particulate Matter (PM_{10}) concentration;
- models the effect of a small number of buildings on dispersion from point sources;
- Models the effect of complex terrain (hills) and spatially varying surface roughness. Terrain effects only become noticeable for gradients greater than 1:10, but for ground level sources in a built up area, such as urban roads, low gradients will have a negligible effect;
- models concentrations in units of $ou_e m^{-3}$ for odour studies;
- link to mapinfo and ArcGIS for input of source geometry, display of sources, aggregation of emissions and plotting of contours; and
- link to an emissions inventory in Microsoft Access for input and export of source and emissions data.

Validation

ADMS-Roads has been validated using UK and US data and has been compared with the Design Manual for Roads and Bridges (DMRB) spreadsheet model and the US model, CALINE. Validation of the ADMS and ADMS-Urban models are also applicable to the performance of ADMS-Roads as they test common features: basic dispersion, modelling of roads and street canyons, the effect of buildings and the effect of complex terrain. These validation studies are all reported on the CERC web site[2]. In addition, ADMS-Urban has been validated during its use in modelling many urban areas in the UK for local authorities as part of Local Air Quality Management (LAQM), Heathrow Airport for the Department for Transport[3] and all of Greater London for a Defra model inter-comparison exercise[4].

[2] Cambridge Environmental Research Consultants (CERC) (2022). Model Validation. (online) Available at: https://www.cerc.co.uk/environmental-software/model-validation.html (Accessed July 2022)
[3] CERC (2007) Air Quality Studies for Heathrow: Base Case, Segregated Mode, Mixed Mode and Third Runway Scenarios Modelled Using ADMS-Airport, prepared for the Department for Transport, HMSO Product code 78APD02904CERC
[4] Carslaw, D. (2011), Defra urban model evaluation analysis – Phase 1, a report to Defra and the Devolved Authorities. (online) Available at: http://uk-air.defra.gov.uk/library/reports?report_id=654 (Accessed 19 October 2021).

ADMS-Roads Input

Table 9B.1 shows the traffic data used in the modelling. Traffic data comprising Annual Average Daily Traffic flows (AADT) and numbers of different vehicle types, was sourced from **Chapter 11: Traffic and Transport**.

The last year with NO_2 monitoring data available prior to the COVID-19 pandemic(which affected pollutant concentrations) was 2019. This year was therefore selected for model verification.

Road widths and height were estimated from information available on Google Street View[5]. Speed limits were used as average speeds, as well as a speed of 20 kmh^{-1} on junction sections.

The traffic data was used to estimate emissions for three scenarios:

- the 2019 baseline used for model verification, based on 2019 traffic flow data, 2019 emission factors and predicted background concentrations [2019 baseline];
- the 2025 future baseline scenario based on 2025 traffic data, emission factors and predicted background concentrations [2025 with development]; and
- the 2025 peak construction year scenario based on 2025 traffic data, emission factors and predicted background concentrations [2025 with development].

[5] Google (2022) Google maps. (Online). Available from: https://www.google.com/maps/ (Accessed July 2022)

Table 9B.1 ADMS-Roads road traffic input data

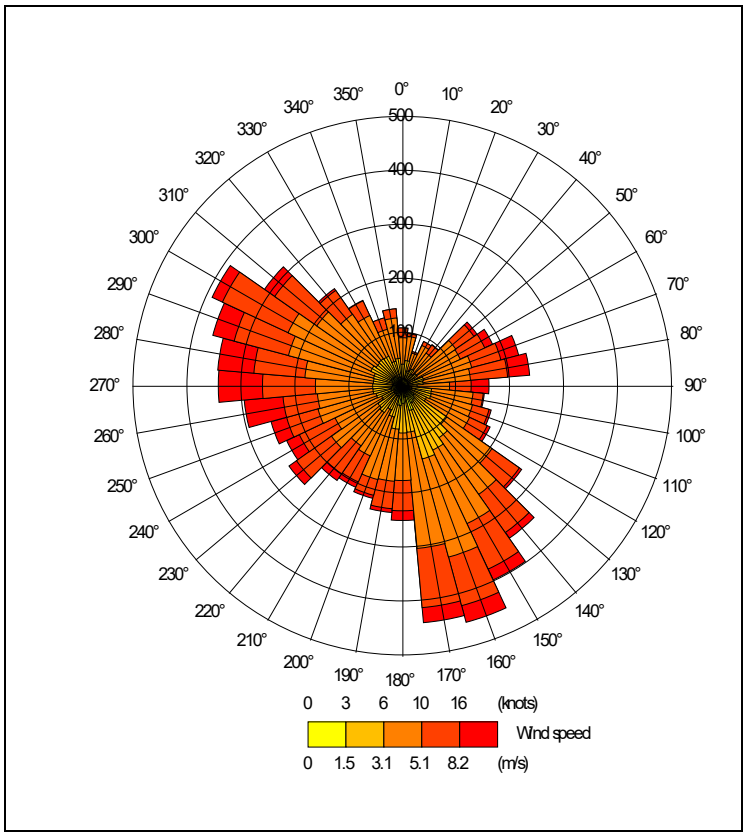
ADMS-Roads Link	Road	Location	2019 AADT	2019 HGV	2025 WOD AADT	2019 WOD HGV	2019 WD AADT	2019 WOD HGV
SRNR3	M6	M6 J21	135,278	14,177	142,832	15,022	143,188	15,314
SRNR5	M60	Between M60 J10 and J9	105,623	7,100	112,371	7,634	112,653	7,744
RW10	A56	Frodsham Town Center	18,642	435	19,126	456	19,206	456
RW10J	A56	Frodsham Town Center	18,642	435	19,126	456	19,206	456
RW3J	A56	River Weaver Bridge	19,119	224	20,218	237	20,486	369
RW3	A56	River Weaver Bridge	19,119	224	20,218	237	20,486	369
SRNR12	M56	Between M6 and Jucntion 10	117,996	13,431	124,585	14,231	125,077	14,601
RN1	A56	Between M56 and A558	26,750	1,849	28,258	1,959	28,871	2,201
SR1J	A49	Between A533 and Willow Green Lane	17,677	1,055	18,811	1,134	19,289	1,360
RE1J	A49	Between Grimsditch Lane and Street Lane	13,710	1,138	14,483	1,206	14,853	1,346
RW4J	A533	Between A49 and Higher Lane	7,810	333	8,250	353	8,705	484

ADMS-Roads Link	Road	Location	2019 AADT	2019 HGV	2025 WOD AADT	2019 WOD HGV	2019 WD AADT	2019 WOD HGV
SR8J	A533	Between Shutley Lane and Broomsfield Lane	7,846	297	8,288	315	8,394	365
SR8	A533	Between Shutley Lane and Broomsfield Lane	7,846	297	8,288	315	8,394	365
SR1	A49	Between A533 and Willow Green Lane	17,677	1,055	18,811	1,134	19,289	1,360
RW4	A533	Between A49 and Higher Lane	7,810	333	8,250	353	8,705	484
RE1	A49	Between Grimsditch Lane and Street Lane	13,710	1,138	14,483	1,206	14,853	1,346
SRNR7	M62	Between M62/M602/M60 and M62 J11	129,948	14,860	137,205	15,745	137,335	15,859
RE9	Woodhouse Lane	Dunham Woodhouses	3,329	112	3,460	119	3,522	119
SRNR10	A556	Between Chapel Lane and M56 J8	48,801	3,868	51,919	4,159	51,991	4,215

Meteorological data

Detailed dispersion modelling requires hourly sequential meteorological data from a representative synoptic observing station. Hourly sequential meteorological data was obtained for Liverpool John Lennon Airport, which is considered to provide representative data for the Preliminary Order Limits. This met station is within 10km of the Preliminary Order Limits of the West Corridor. **Graphic 9B.1** summarises the hourly wind speed and wind direction for the meteorological data as a wind rose.

Graphic 9B1 Liverpool John Lennon Airport Wind Rose



Source: ADMS-Roads v5.2

Estimated background pollutant concentrations

Defra has made estimates of background pollution concentrations on a 1 km^2 grid for the UK for seven of the main pollutants, including NO_2, PM_{10} and $PM_{2.5}$, using data for a base year of 2018, making projections for years from 2018 to 2030 inclusive[6].

Table 9B.2 shows the estimated values of the pollutants for 2019 and 2025 for the cells used in the modelling.

[6] Department for Environment Food & Rural Affairs (Defra) (2022). Background Mapping data for local authorities – 2018. (Online). Available at: https://uk-air.defra.gov.uk/data/laqm-background-maps?year=2018 (Accessed July 2022)

Table 9B2 Mapped background annual mean pollutant concentrations (µgm^{-3})

Grid Square	2019 NO_X	2019 NO_2	2019 PM_{10}	2019 $PM_{2.5}$	2025 NO_X	2025 NO_2	2025 PM_{10}	2025 $PM_{2.5}$
351500_378500	23.8	17.2	14.3	8.6	17.1	12.8	13.5	8.0
352500_378500	22.5	16.4	13.3	8.4	16.5	12.4	12.6	7.8
360500_381500	19.8	14.7	13.0	8.0	14.0	10.7	12.3	7.4
366500_389500	25.0	18.0	13.5	8.4	17.8	13.2	12.8	7.8
376500_396500	35.1	23.6	14.4	9.4	26.5	18.6	13.6	8.8
377500_396500	29.8	20.7	13.8	8.9	22.0	15.9	13.0	8.3
364500_390500	33.8	23.1	13.5	8.8	23.9	17.1	12.7	8.2
357500_382500	20.6	15.0	12.0	7.8	16.1	12.0	11.2	7.2
360500_377500	12.1	9.3	11.5	7.0	9.4	7.4	10.8	6.5
360500_376500	12.3	9.4	11.5	7.0	9.8	7.6	10.8	6.5
361500_377500	11.0	8.5	11.1	6.8	8.7	6.8	10.4	6.3
368500_393500	26.7	19.0	13.5	8.4	18.7	13.9	12.7	7.8
366500_388500	28.6	20.2	12.7	8.1	19.6	14.5	11.9	7.5
374500_387500	15.0	11.3	10.5	6.9	11.6	8.9	9.8	6.3
373500_384500	19.4	14.4	11.6	7.4	14.1	10.7	10.9	6.9

ADMS-Roads Model Verification

The ADMS-Roads dispersion model has been widely validated for this type of assessment and is specifically listed in the Defra's LAQM Technical Guidance (LAQM.TG(16))[7] guidance as an accepted dispersion model.

Model validation undertaken by the software developer (CERC) will not have included validation in the vicinity of the Preliminary Order Limits. It is therefore necessary to perform a comparison of modelled results with local monitoring data at relevant locations. This process of verification attempts to minimise modelling uncertainty and systematic error by correcting modelled results by an adjustment factor to gain greater confidence in the final results.

[7] Defra (2021) LAQM Technical Guidance. (online) Available from: https://laqm.defra.gov.uk/air-quality/featured/uk-regions-exc-london-technical-guidance/ (Accessed July 2022).

The predicted results from a dispersion model may differ from measured concentrations for a large number of reasons, including uncertainties associated with:

- background concentration estimates;
- meteorological data;
- source activity data such as traffic flows and emissions factors;
- model input parameters such as surface roughness length, minimum monin-obukhov length;
- monitoring data, including locations; and
- overall model limitations.

Model verification is the process by which these and other uncertainties are investigated and where possible minimised. In reality the differences between modelled and monitored results are likely to be a combination of all of these aspects.

Model setup parameters and input data were checked prior to running the models in order to reduce these uncertainties, as follows:

- traffic data;
- road widths;
- distance between sources and monitoring as represented in the model;
- speed estimates on roads;
- source types, such as elevated roads and street canyons;
- selection of representative meteorological data;
- background monitoring and background estimates; and
- monitoring data.

Suitable local monitoring data for the purpose of verification is available for annual mean NO_X/NO_2 concentrations as shown in **Table 9B.3.** The monitoring locations presented were selected to provide suitable worst-case adjustment factors for two types of road traffic emission source: around the Strategic Road Network (SRN); and on local roads.

Table 9B.3 Local monitoring data suitable for ADMS-Roads model verification

Location	Type	2019 Annual Mean NO_2 (μgm^{-3})	X (m)	Y (m)
CW_FH	Local	36.9	352146	378139
CW_FJ	Local	36.9	352171	378140
WARR_DT5	SRN	41.0	366084	389210
TR23NO	SRN	36.6	376438	396383

Verification calculations

The verification of the modelling output was performed in accordance with the methodology provided in Annex 3 of LAQM.TG(16)[7]. **Table 9B.4** shows that there was the systematic under prediction of monitored concentrations for all sites.

Table 9B4 Verification, modelled versus monitored

Site	2019 Modelled Annual Mean NO_2 (μgm^{-3})	2019 Monitored Annual Mean NO_2 (μgm^{-3})	% (Modelled-Monitored)/ Monitored
CW_FH	21.9	36.9	-40.62%
CW_FJ	21.3	36.9	-42.41%
WARR_DT5	28.8	41.0	-29.71%
TR23NO	29.9	36.6	-18.44%

Table 9B.5 shows the comparison of modelled road-NO_X, a direct output from the ADMS-Roads modelling, with the monitored road-NO_X, determined from the LAQM NO_X to NO_2 conversion tool.

Table 9B5 Comparison of modelled and monitored road NO_X to determine verification factor

Site	2019 Modelled Annual Mean Road NO_X (μgm^{-3})	2019 Monitored Annual Mean Road NO_X (μgm^{-3})	Ratio
CW_FH	10.4	41.0	4.0
CW_FJ	9.1	41.0	4.5
WARR_DT5	20.9	46.8	2.2
TR23NO	12.1	25.9	2.1

Table 9B.6 shows the comparison of the modelled NO_2 concentration calculated by multiplying the modelled road NO_X by the adjustment factors of 2.2 for the SRN and 4.2 for local roads and using the LAQM's NO_X to NO_2 conversion tool to calculate the total adjusted modelled NO_2.

Table 9B.6 Comparison of adjusted modelled NO_2 and modelled NO_2

Site	2019 Background NO_2 Concentration (μgm^{-3})	2018=9 Adjusted Modelled Annual Mean NO_2 (μgm^{-3})	2019 Monitored Annual Mean NO_2 (μgm^{-3})	% (Adjusted Modelled-Monitored)/ Monitored
CW_FH	16.4	38.2	36.9	3.6%
CW_FJ	16.4	35.7	36.9	-3.1%
WARR_DT5	18.0	40.5	41.0	-1.1%
TR23NO	23.6	36.9	36.6	0.8%

ADMS-Roads Model Results – Human Health Receptors

The predicted annual mean NO_2 concentrations for each human receptor considered in this assessment are reported below in **Table 9B.8**. **Table 9B.9** and **Table 9B.10** report the predicted annual mean concentrations for PM_{10} and $PM_{2.5}$ respectively.

Table 9B.8 Annual mean NO_2 predicted concentrations (μgm^{-3})

Model ID	2019	2025 WOD	2025 WD	Difference	Difference (%)	Impact Magnitude
CW_FTG	54.3	34.8	34.9	0.08	0%	Negligible
CW_FRC	51.8	33.2	33.3	0.08	0%	Negligible
CW_FH	38.2	25.0	25.0	0.07	0%	Negligible
CW_FJ	35.7	23.6	23.7	0.12	0%	Negligible
WARR_DT7	44.3	27.3	27.3	0.04	0%	Negligible
WARR_DT5	40.5	25.7	25.7	0.01	0%	Negligible
TR23NO	36.9	26.0	26.0	0.02	0%	Negligible
TR23ANO	32.1	23.2	23.2	0.01	0%	Negligible
Benbecula Way	53.6	35.8	35.9	0.03	0%	Negligible

Model ID	2019	2025 WOD	2025 WD	Difference	Difference (%)	Impact Magnitude
Harris Avenue	54.1	36.1	36.2	0.03	0%	Negligible
Iona Way	51.3	33.5	33.5	0.04	0%	Negligible
Manchester Road	48.2	30.2	30.2	0.03	0%	Negligible
Keepers Cottage	30.7	19.4	19.4	0.03	0%	Negligible
Ring O Bells	19.4	14.4	14.4	0.04	0%	Negligible
Delph Lane	19.9	14.7	14.7	0.04	0%	Negligible
78 High Street	45.8	29.7	29.8	0.15	0%	Negligible
68 High Street	53.1	34.1	34.2	0.09	0%	Negligible
67 High Street	45.3	29.2	29.3	0.07	0%	Negligible
59 High Street	40.4	26.2	26.3	0.05	0%	Negligible
1 Bridge Street	39.0	25.9	26.2	0.34	1%	Negligible
49 Bridge Street	39.3	26.2	26.6	0.39	1%	Negligible
The Croft	35.3	22.1	22.8	0.69	2%	Negligible
White House	23.4	15.1	15.5	0.38	1%	Negligible
Hollybush Cottage	32.6	20.7	21.3	0.61	2%	Negligible
Sonora	42.4	26.6	27.4	0.86	2%	Negligible
Idene	18.6	12.5	12.9	0.37	1%	Negligible
Happy Guest Lodge	22.2	14.4	14.7	0.24	1%	Negligible
Laburnum Cottage	17.2	11.7	11.8	0.08	0%	Negligible
Meadow Farm	17.8	12.0	12.1	0.11	0%	Negligible

Table 9B.9 Annual mean PM_{10} predicted concentrations (μgm^{-3})

Model ID	2019	2025 WOD	2025 WD	Difference	Difference (%)	Impact Magnitude
CW_FTG	16.7	15.8	15.8	0.01	0%	Negligible
CW_FRC	15.6	14.7	14.7	0.01	0%	Negligible
CW_FH	14.7	13.8	13.8	0.01	0%	Negligible
CW_FJ	14.5	13.6	13.7	0.01	0%	Negligible
WARR_DT7	16.3	15.3	15.4	0.03	0%	Negligible
WARR_DT5	15.9	15.0	15.0	0.02	0%	Negligible
TR23NO	15.7	14.8	14.8	0.01	0%	Negligible
TR23ANO	15.2	14.4	14.4	0.00	0%	Negligible
Benbecula Way	17.5	16.5	16.5	0.01	0%	Negligible
Harris Avenue	17.6	16.5	16.6	0.01	0%	Negligible
Iona Way	16.9	15.9	15.9	0.01	0%	Negligible
Manchester Road	16.9	15.9	15.9	0.02	0%	Negligible
Keepers Cottage	14.7	13.8	13.9	0.02	0%	Negligible
Ring O Bells	12.6	11.7	11.8	0.02	0%	Negligible
Delph Lane	12.6	11.8	11.8	0.02	0%	Negligible
78 High Street	15.2	14.3	14.3	0.02	0%	Negligible
68 High Street	15.7	14.8	14.8	0.01	0%	Negligible
67 High Street	15.1	14.2	14.2	0.01	0%	Negligible
59 High Street	15.7	14.9	14.9	0.01	0%	Negligible
1 Bridge Street	14.7	13.9	13.9	0.04	0%	Negligible
49 Bridge Street	14.8	13.9	14.0	0.04	0%	Negligible
The Croft	13.0	12.2	12.3	0.08	0%	Negligible
White House	12.3	11.5	11.6	0.04	0%	Negligible
Hollybush Cottage	12.8	12.0	12.1	0.07	0%	Negligible
Sonora	13.4	12.7	12.8	0.10	0%	Negligible

Model ID	2019	2025 WOD	2025 WD	Difference	Difference (%)	Impact Magnitude
Idene	12.0	11.3	11.3	0.04	0%	Negligible
Happy Guest Lodge	12.4	11.7	11.7	0.04	0%	Negligible
Laburnum Cottage	11.7	11.0	11.0	0.02	0%	Negligible
Meadow Farm	12.1	11.4	11.4	0.03	0%	Negligible

Table 9B10 Annual mean $PM_{2.5}$ predicted concentrations (μgm^{-3})

Model ID	2019	2025 WOD	2025 WD	Difference	Difference (%)	Impact Magnitude
CW_FTG	11.0	9.3	9.3	0.01	0%	Negligible
CW_FRC	10.7	9.1	9.1	0.01	0%	Negligible
CW_FH	9.7	8.5	8.5	0.01	0%	Negligible
CW_FJ	9.6	8.4	8.4	0.01	0%	Negligible
WARR_DT7	11.3	9.3	9.3	0.02	0%	Negligible
WARR_DT5	10.8	9.2	9.2	0.01	0%	Negligible
TR23NO	10.7	9.6	9.6	0.00	0%	Negligible
TR23ANO	10.2	9.3	9.3	0.00	0%	Negligible
Benbecula Way	12.6	10.6	10.6	0.01	0%	Negligible
Harris Avenue	12.6	10.7	10.7	0.01	0%	Negligible
Iona Way	12.0	10.1	10.1	0.01	0%	Negligible
Manchester Road	11.7	9.7	9.7	0.01	0%	Negligible
Keepers Cottage	9.7	8.4	8.4	0.01	0%	Negligible
Ring O Bells	8.4	7.5	7.5	0.01	0%	Negligible
Delph Lane	8.4	7.5	7.5	0.01	0%	Negligible
78 High Street	10.2	8.8	8.8	0.01	0%	Negligible
68 High Street	10.8	9.1	9.1	0.01	0%	Negligible
67 High Street	10.2	8.8	8.8	0.00	0%	Negligible

Model ID	2019	2025 WOD	2025 WD	Difference	Difference (%)	Impact Magnitude
59 High Street	10.0	8.8	8.8	0.00	0%	Negligible
1 Bridge Street	9.8	8.6	8.6	0.02	0%	Negligible
49 Bridge Street	9.8	8.6	8.6	0.03	0%	Negligible
The Croft	8.5	7.3	7.4	0.05	0%	Negligible
White House	7.8	6.9	7.0	0.02	0%	Negligible
Hollybush Cottage	8.4	7.2	7.3	0.04	0%	Negligible
Sonora	9.0	7.6	7.7	0.06	0%	Negligible
Idene	7.6	6.8	6.8	0.02	0%	Negligible
Happy Guest Lodge	8.0	7.0	7.0	0.03	0%	Negligible
Laburnum Cottage	7.4	6.6	6.6	0.01	0%	Negligible
Meadow Farm	7.7	6.8	6.9	0.02	0%	Negligible

ADMS-Roads Model Results – Ecological Receptors

Table 9B.11 reports the transect points used within the ADMS-Roads model to model the air quality impacts at each ecological receptor. **Table 9B.12** and **Table 9B.13** report the predicted annual mean NO_x and the predicted daily mean NO_x concentrations respectively.

The total nitrogen deposition predicted at each modelled transect is reported within **Table 9B.14**. The predicted acid deposition at each modelled transect is reported within **Table 9B.15.**

Table 9B.11 Modelled transect points

Transect ID	X	Y
Holcroft Moss_1	368306	393444
Holcroft Moss_2	368313	393425
Holcroft Moss_3	368321	393406
Holcroft Moss_4	368328	393387
Holcroft Moss_5	368335	393368
Holcroft Moss_6	368343	393350
Holcroft Moss_7	368350	393331
Holcroft Moss_8	368357	393312
Holcroft Moss_9	368364	393293
Holcroft Moss_10	368372	393274
Holcroft Moss_11	368379	393255
Woolston Eyes_E1	366450	388577
Woolston Eyes_E2	366470	388581
Woolston Eyes_E3	366489	388586
Woolston Eyes_E4	366509	388590
Woolston Eyes_E5	366528	388595
Woolston Eyes_E6	366548	388599
Woolston Eyes_E7	366567	388603
Woolston Eyes_E8	366587	388608
Woolston Eyes_E9	366606	388612

Transect ID	X	Y
Woolston Eyes_E10	366626	388617
Woolston Eyes_E11	366645	388621
Woolston Eyes_W1	366348	388589
Woolston Eyes_W2	366329	388583
Woolston Eyes_W3	366310	388577
Woolston Eyes_W4	366291	388571
Woolston Eyes_W5	366272	388565
Woolston Eyes_W6	366253	388559
Woolston Eyes_W7	366233	388552
Woolston Eyes_W8	366214	388546
Woolston Eyes_W9	366195	388540
Woolston Eyes_W10	366176	388534
Woolston Eyes_W11	366157	388528
Dunham Park_1	374016	387454
Dunham Park_2	374016	387434
Dunham Park_3	374016	387414
Dunham Park_4	374016	387394
Dunham Park_5	374016	387374
Dunham Park_6	374016	387354
Dunham Park_7	374016	387334
Dunham Park_8	374016	387314
Dunham Park_9	374016	387294
Dunham Park_10	374016	387274
Dunham Park_11	374016	387254
Rostherne Mere_1	373715	384628
Rostherne Mere_2	373733	384618

Transect ID	X	Y
Rostherne Mere_3	373750	384608
Rostherne Mere_4	373768	384599
Rostherne Mere_5	373785	384589
Rostherne Mere_6	373803	384579

Table 9B.12 Predicted annual mean NO_x concentrations (μgm^{-3})

	2025 WOD	2025 WD	Difference	Difference (%)
Holcroft Moss_1	50.28	50.30	0.02	0.07%
Holcroft Moss_2	39.05	39.06	0.01	0.04%
Holcroft Moss_3	33.73	33.74	0.01	0.03%
Holcroft Moss_4	30.62	30.62	0.01	0.03%
Holcroft Moss_5	28.55	28.56	0.01	0.02%
Holcroft Moss_6	27.09	27.09	0.01	0.02%
Holcroft Moss_7	25.99	26.00	0.00	0.02%
Holcroft Moss_8	25.15	25.15	0.00	0.01%
Holcroft Moss_9	24.47	24.47	0.00	0.01%
Holcroft Moss_10	23.91	23.91	0.00	0.01%
Holcroft Moss_11	23.44	23.45	0.00	0.01%
Woolston Eyes_E1	45.53	45.57	0.04	0.14%
Woolston Eyes_E2	39.03	39.06	0.03	0.11%
Woolston Eyes_E3	35.17	35.19	0.03	0.09%
Woolston Eyes_E4	32.59	32.61	0.02	0.07%
Woolston Eyes_E5	30.76	30.78	0.02	0.06%
Woolston Eyes_E6	29.36	29.38	0.02	0.05%
Woolston Eyes_E7	28.28	28.30	0.01	0.05%
Woolston Eyes_E8	27.42	27.43	0.01	0.04%
Woolston Eyes_E9	26.71	26.72	0.01	0.04%

	2025 WOD	2025 WD	Difference	Difference (%)
Woolston Eyes_E10	26.11	26.12	0.01	0.04%
Woolston Eyes_E11	25.61	25.62	0.01	0.03%
Woolston Eyes_W1	55.86	55.92	0.06	0.20%
Woolston Eyes_W2	43.20	43.24	0.04	0.13%
Woolston Eyes_W3	37.24	37.27	0.03	0.10%
Woolston Eyes_W4	33.73	33.76	0.02	0.08%
Woolston Eyes_W5	31.41	31.43	0.02	0.07%
Woolston Eyes_W6	29.77	29.79	0.02	0.06%
Woolston Eyes_W7	28.53	28.54	0.02	0.05%
Woolston Eyes_W8	27.57	27.58	0.01	0.04%
Woolston Eyes_W9	26.80	26.81	0.01	0.04%
Woolston Eyes_W10	26.17	26.18	0.01	0.04%
Woolston Eyes_W11	25.65	25.66	0.01	0.03%
Dunham Park_1	15.15	15.21	0.06	0.19%
Dunham Park_2	13.29	13.32	0.02	0.08%
Dunham Park_3	12.82	12.83	0.02	0.05%
Dunham Park_4	12.60	12.61	0.01	0.04%
Dunham Park_5	12.47	12.48	0.01	0.03%
Dunham Park_6	12.38	12.39	0.01	0.03%
Dunham Park_7	12.32	12.33	0.01	0.02%
Dunham Park_8	12.28	12.28	0.01	0.02%
Dunham Park_9	12.25	12.25	0.01	0.02%
Dunham Park_10	12.22	12.22	0.00	0.02%
Dunham Park_11	12.20	12.20	0.00	0.01%
Rostherne Mere_1	29.10	29.12	0.01	0.05%
Rostherne Mere_2	23.28	23.29	0.01	0.03%

	2025 WOD	2025 WD	Difference	Difference (%)
Rostherne Mere_3	20.73	20.74	0.01	0.02%
Rostherne Mere_4	19.28	19.29	0.01	0.02%
Rostherne Mere_5	18.35	18.35	0.00	0.01%
Rostherne Mere_6	17.69	17.70	0.00	0.01%
Rostherne Mere_7	17.21	17.21	0.00	0.01%
Rostherne Mere_8	16.84	16.84	0.00	0.01%
Rostherne Mere_9	16.55	16.55	0.00	0.01%
Rostherne Mere_10	16.31	16.31	0.00	0.01%
Rostherne Mere_11	16.11	16.11	0.00	0.01%

Table 9B.13 Predicted daily mean NO_x concentrations (μgm^{-3})

	2025 WOD	2025 WD	Difference	Difference (%)
Holcroft Moss_1	68.99	69.01	0.02	0.03%
Holcroft Moss_2	57.76	57.78	0.01	0.02%
Holcroft Moss_3	52.45	52.46	0.01	0.01%
Holcroft Moss_4	49.33	49.34	0.01	0.01%
Holcroft Moss_5	47.27	47.28	0.01	0.01%
Holcroft Moss_6	45.80	45.81	0.01	0.01%
Holcroft Moss_7	44.71	44.71	0.00	0.01%
Holcroft Moss_8	43.86	43.87	0.00	0.01%
Holcroft Moss_9	43.19	43.19	0.00	0.01%
Holcroft Moss_10	42.62	42.63	0.00	0.00%
Holcroft Moss_11	42.16	42.16	0.00	0.00%
Woolston Eyes_E1	65.16	65.20	0.04	0.06%
Woolston Eyes_E2	58.67	58.70	0.03	0.04%
Woolston Eyes_E3	54.80	54.83	0.03	0.03%
Woolston Eyes_E4	52.23	52.25	0.02	0.03%

	2025 WOD	2025 WD	Difference	Difference (%)
Woolston Eyes_E5	50.39	50.41	0.02	0.02%
Woolston Eyes_E6	49.00	49.02	0.02	0.02%
Woolston Eyes_E7	47.92	47.93	0.01	0.02%
Woolston Eyes_E8	47.06	47.07	0.01	0.02%
Woolston Eyes_E9	46.35	46.36	0.01	0.02%
Woolston Eyes_E10	45.74	45.76	0.01	0.01%
Woolston Eyes_E11	45.24	45.25	0.01	0.01%
Woolston Eyes_W1	75.49	75.55	0.06	0.08%
Woolston Eyes_W2	62.83	62.87	0.04	0.05%
Woolston Eyes_W3	56.88	56.91	0.03	0.04%
Woolston Eyes_W4	53.37	53.39	0.02	0.03%
Woolston Eyes_W5	51.04	51.06	0.02	0.03%
Woolston Eyes_W6	49.41	49.42	0.02	0.02%
Woolston Eyes_W7	48.16	48.18	0.02	0.02%
Woolston Eyes_W8	47.20	47.21	0.01	0.02%
Woolston Eyes_W9	46.43	46.44	0.01	0.02%
Woolston Eyes_W10	45.80	45.81	0.01	0.01%
Woolston Eyes_W11	45.28	45.29	0.01	0.01%
Dunham Park_1	26.73	26.79	0.06	0.08%
Dunham Park_2	24.87	24.90	0.02	0.03%
Dunham Park_3	24.39	24.41	0.02	0.02%
Dunham Park_4	24.17	24.19	0.01	0.02%
Dunham Park_5	24.05	24.05	0.01	0.01%
Dunham Park_6	23.96	23.97	0.01	0.01%
Dunham Park_7	23.90	23.91	0.01	0.01%
Dunham Park_8	23.86	23.86	0.01	0.01%

	2025 WOD	2025 WD	Difference	Difference (%)
Dunham Park_9	23.82	23.83	0.01	0.01%
Dunham Park_10	23.80	23.80	0.00	0.01%
Dunham Park_11	23.78	23.78	0.00	0.01%
Rostherne Mere_1	43.16	43.18	0.01	0.02%
Rostherne Mere_2	37.35	37.36	0.01	0.01%
Rostherne Mere_3	34.80	34.80	0.01	0.01%
Rostherne Mere_4	33.34	33.35	0.01	0.01%
Rostherne Mere_5	32.41	32.41	0.00	0.01%
Rostherne Mere_6	31.75	31.76	0.00	0.00%
Rostherne Mere_7	31.27	31.28	0.00	0.00%
Rostherne Mere_8	30.90	30.91	0.00	0.00%
Rostherne Mere_9	30.61	30.61	0.00	0.00%
Rostherne Mere_10	30.37	30.37	0.00	0.00%
Rostherne Mere_11	30.17	30.17	0.00	0.00%

Table 9B.14 Total nitrogen deposition (kg N $ha^{-1}yr^{-1}$)

	2025 WOD	2025 WD	Difference	Difference (%) CL
Holcroft Moss_1	12.31	12.31	0.0014	0.01%
Holcroft Moss_2	11.52	11.52	0.0000	0.00%
Holcroft Moss_3	11.13	11.13	0.0014	0.01%
Holcroft Moss_4	10.90	10.90	0.0014	0.01%
Holcroft Moss_5	10.74	10.74	0.0000	0.00%
Holcroft Moss_6	10.63	10.63	0.0014	0.01%
Holcroft Moss_7	10.55	10.55	0.0014	0.01%
Holcroft Moss_8	10.48	10.49	0.0014	0.01%
Holcroft Moss_9	10.43	10.43	0.0014	0.01%

	2025 WOD	2025 WD	Difference	Difference (%) CL
Holcroft Moss_10	10.39	10.39	0.0014	0.01%
Holcroft Moss_11	10.35	10.35	0.0014	0.01%
Woolston Eyes_E1	11.31	11.31	0.0029	0.01%
Woolston Eyes_E2	10.85	10.85	0.0014	0.01%
Woolston Eyes_E3	10.57	10.57	0.0014	0.01%
Woolston Eyes_E4	10.38	10.38	0.0014	0.01%
Woolston Eyes_E5	10.24	10.24	0.0014	0.01%
Woolston Eyes_E6	10.13	10.14	0.0014	0.01%
Woolston Eyes_E7	10.05	10.05	0.0014	0.01%
Woolston Eyes_E8	9.99	9.99	0.0000	0.00%
Woolston Eyes_E9	9.93	9.93	0.0014	0.01%
Woolston Eyes_E10	9.89	9.89	0.0014	0.01%
Woolston Eyes_E11	9.85	9.85	0.0014	0.01%
Woolston Eyes_W1	12.02	12.02	0.0043	0.02%
Woolston Eyes_W2	11.15	11.15	0.0029	0.01%
Woolston Eyes_W3	10.72	10.72	0.0029	0.01%
Woolston Eyes_W4	10.46	10.46	0.0029	0.01%
Woolston Eyes_W5	10.29	10.29	0.0029	0.01%
Woolston Eyes_W6	10.17	10.17	0.0014	0.01%
Woolston Eyes_W7	10.07	10.07	0.0014	0.01%
Woolston Eyes_W8	10.00	10.00	0.0014	0.01%
Woolston Eyes_W9	9.94	9.94	0.0000	0.00%
Woolston Eyes_W10	9.89	9.89	0.0014	0.01%
Woolston Eyes_W11	9.85	9.85	0.0014	0.01%
Dunham Park_1	12.65	12.66	0.0043	0.04%
Dunham Park_2	12.51	12.51	0.0014	0.01%

	2025 WOD	2025 WD	Difference	Difference (%) CL
Dunham Park_3	12.47	12.47	0.0000	0.00%
Dunham Park_4	12.45	12.45	0.0014	0.01%
Dunham Park_5	12.44	12.44	0.0014	0.01%
Dunham Park_6	12.43	12.43	0.0000	0.00%
Dunham Park_7	12.43	12.43	0.0014	0.01%
Dunham Park_8	12.43	12.43	0.0000	0.00%
Dunham Park_9	12.42	12.42	0.0000	0.00%
Dunham Park_10	12.42	12.42	0.0000	0.00%
Dunham Park_11	12.42	12.42	0.0014	0.01%
Rostherne Mere_1	27.93	27.93	0.0000	0.00%
Rostherne Mere_2	27.49	27.49	0.0014	0.01%
Rostherne Mere_3	27.29	27.29	0.0000	0.00%
Rostherne Mere_4	27.18	27.18	0.0014	0.01%
Rostherne Mere_5	27.11	27.11	0.0000	0.00%
Rostherne Mere_6	27.05	27.05	0.0000	0.00%
Rostherne Mere_7	27.02	27.02	0.0000	0.00%
Rostherne Mere_8	26.99	26.99	0.0000	0.00%
Rostherne Mere_9	26.96	26.96	0.0000	0.00%
Rostherne Mere_10	26.95	26.95	0.0000	0.00%
Rostherne Mere_11	26.93	26.93	0.0000	0.00%

Table 9B.15 Total acid deposition (kg N $ha^{-1}yr^{-1}$)

	2025 WOD	2025 WD	Difference	Difference (%) CL
Holcroft Moss_1	1.02	1.02	0.000	0.03%
Holcroft Moss_2	0.97	0.97	0.0000	0.00%
Holcroft Moss_3	0.94	0.94	0.0001	0.03%

	2025 WOD	2025 WD	Difference	Difference (%) CL
Holcroft Moss_4	0.92	0.92	0.0001	0.03%
Holcroft Moss_5	0.91	0.91	0.0000	0.00%
Holcroft Moss_6	0.90	0.90	0.0001	0.03%
Holcroft Moss_7	0.90	0.90	0.0001	0.03%
Holcroft Moss_8	0.89	0.89	0.0001	0.03%
Holcroft Moss_9	0.89	0.89	0.0001	0.03%
Holcroft Moss_10	0.89	0.89	0.0001	0.03%
Holcroft Moss_11	0.88	0.88	0.0001	0.03%
Woolston Eyes_E1	0.93	0.93	0.0002	0.05%
Woolston Eyes_E2	0.90	0.90	0.0001	0.03%
Woolston Eyes_E3	0.88	0.88	0.0001	0.03%
Woolston Eyes_E4	0.86	0.86	0.0001	0.03%
Woolston Eyes_E5	0.85	0.85	0.0001	0.03%
Woolston Eyes_E6	0.85	0.85	0.0001	0.03%
Woolston Eyes_E7	0.84	0.84	0.0001	0.03%
Woolston Eyes_E8	0.84	0.84	0.0000	0.00%
Woolston Eyes_E9	0.83	0.83	0.0001	0.03%
Woolston Eyes_E10	0.83	0.83	0.0001	0.03%
Woolston Eyes_E11	0.83	0.83	0.0001	0.03%
Woolston Eyes_W1	0.98	0.98	0.0003	0.08%
Woolston Eyes_W2	0.92	0.92	0.0002	0.05%
Woolston Eyes_W3	0.89	0.89	0.0002	0.05%
Woolston Eyes_W4	0.87	0.87	0.0002	0.05%
Woolston Eyes_W5	0.86	0.86	0.0002	0.05%
Woolston Eyes_W6	0.85	0.85	0.0001	0.03%
Woolston Eyes_W7	0.84	0.84	0.0001	0.03%

	2025 WOD	2025 WD	Difference	Difference (%) CL
Woolston Eyes_W8	0.84	0.84	0.0001	0.03%
Woolston Eyes_W9	0.83	0.83	0.0000	0.00%
Woolston Eyes_W10	0.83	0.83	0.0001	0.03%
Woolston Eyes_W11	0.83	0.83	0.0001	0.03%
Dunham Park_1	1.02	1.02	0.0003	0.09%
Dunham Park_2	1.01	1.01	0.0001	0.03%
Dunham Park_3	1.00	1.00	0.0000	0.00%
Dunham Park_4	1.00	1.00	0.0001	0.03%
Dunham Park_5	1.00	1.00	0.0001	0.03%
Dunham Park_6	1.00	1.00	0.0000	0.00%
Dunham Park_7	1.00	1.00	0.0001	0.03%
Dunham Park_8	1.00	1.00	0.0000	0.00%
Dunham Park_9	1.00	1.00	0.0000	0.00%
Dunham Park_10	1.00	1.00	0.0000	0.00%
Dunham Park_11	1.00	1.00	0.0001	0.03%
Rostherne Mere_1	1.98	1.98	0.0000	0.00%
Rostherne Mere_2	1.95	1.95	0.0001	0.05%
Rostherne Mere_3	1.93	1.93	0.0000	0.00%
Rostherne Mere_4	1.93	1.93	0.0001	0.05%
Rostherne Mere_5	1.92	1.92	0.0000	0.00%
Rostherne Mere_6	1.92	1.92	0.0000	0.00%
Rostherne Mere_7	1.91	1.91	0.0000	0.00%
Rostherne Mere_8	1.91	1.91	0.0000	0.00%
Rostherne Mere_9	1.91	1.91	0.0000	0.00%
Rostherne Mere_10	1.91	1.91	0.0000	0.00%
Rostherne Mere_11	1.91	1.91	0.0000	0.00%

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